INDIAN TEA ASSOCIATION

SCIENTIFIC DEPARTMEMT

TOCKLAI EXPERIMENTAL STATION

ANNUAL REPORT—1940

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The health of the staff during the year has been normal. Unfortunately during the latter part of the year Mr. Mitchell, Advisory Officer in the Dooars, was ill.

Owing to the war 4 Officers have been called up for military service, namely, Mr. L. C. Comrie, Dr. W. Wight, Mr. E. J. Winter and Dr. E. K. Woodford.

In April Mr. Cooper left Tocklai on retirement. I wish to record my very great regret that he has felt obliged to take this step. He joined the Department in November, 1914. In 1916 he joined the I.A.R.O. and was on military service in Mesopotamia. In 1919, he returned to Tocklai as Senior Chemist. Between 1914 and 1916, he supervised the planting out of tea at Tocklai and the early planting at Borbhetta. On return from military duties he again supervised the field work and was responsible for the development of the field experiments both in regard to their objective and their technique. He had a great appreciation of the practical side of tea planting particularly in regard to the field work and his advice on manuring was much appreciated. His most important contributions, and those by which he will be most remembered, are in connection with the adaptation of modern statistical methods to tea experimentation, and his publications "Nitrogen Supply to Tea" and "Experiments with Cattle Manure, Humus Composts and Unfermented Organic Waste Materials."

Mr. Cooper's loyal and sympathetic co-operation is much missed.

The various buildings have been maintained and the new bungalow has been completed and is now occupied by Mr. N. M. Macgregor.

A bungalow at Rungneet Tea Estate has been rented for the Advisory Officer in the Darjeeling district.

A bungalow has been built at Nagrakata in the Dooars for the Advisory Officer in the Dooars.

A bungalow is in course of erection at Shamshernagar in Sylhet for the Advisory Officer in the Surma Valley.

ouring

Both in the Surma Valley and the Darjeeling districts the Advisory Officers made extensive tours throughout their respective districts. Owing to Mr. Mitchell's illness, touring in the Dooars could be done only to a limited extent.

In addition the Officers from Tocklai have visited the undernoted districts:—

Assam—Dibrugarh, Margherita, Moran.

Surma Valley—Chargola-Longai, Chutla Bheel, Lakhipur, Lungla-Juri, Luskerpore, North Cachar.

Dooars—Binnaguri, Chalsa, Dalgaon, Dam Dim.

Darjeeling.

Terai.

Annual Conference

The Fourth Annual Conference was held in February at which the following representatives were present:

Mr. R. B. Lagden ... Indian Tea Association, Calcutta.

Mr. R. L. McLennan, ,, M. H. Burton., ,, R. G. Boyle. } Assam Branch, Indian Tea Association.

Mr. S. A. Pearson., ,, W. Cullen. } Surma Valley Branch, Indian Tea Association.

Mr. D. T. Scott., ,, L. Tocher. } Dooars Planters' Association.

Mr. J. M. Evenden ... Darjeeling Planters' Association.

Mr. D. H. Mackay ... Visitor from Calcutta.

Lecture Courses

Owing to the war it was considered inadvisable to hold the Lecture Courses at the end of the year.

Correspondence

Correspondence during the year has amounted to:

Letters received	...	5,085
Letters despatched	...	6,907

Specimen

The number of samples received during the year were as follows:—

Chemical Branch	...	722
Entomological Branch	...	161
Mycological Branch	...	1,122
Bacteriological Branch	...	93
Botanical Branch	...	21

Three Circulars and two Memoranda have been published during the year:—

Circulars.—Tests for Bacterial infection in Factories.

Some points of interest from the past year's work of the Scientific Department.

Some points on the sorting of tea.

Memoranda.—Experiments with Cattle Manure, Humus Composts and Unfermented Organic Waste Materials.

The species of shade trees used on tea gardens.

During the year manufacturing experiments have been limited owing to the impossibility of getting sufficient tasters' reports on any particular experiment. It was not considered worth the expenditure of energy and time to carry out experiments that could not receive proper examination and which could only give results of doubtful accuracy. I wish however to record my great appreciation of the help that we have received from those tasters in Calcutta who have remained available.

A small pilot plant for the extraction of caffeine from tea waste has been erected. Various technical difficulties have been overcome and the plant now works satisfactorily.

Experiments on Estates.—The 44 experiments carried out on commercial estates have been well and carefully maintained and I take this opportunity of thanking all those managers who have so willingly co-operated with us.

The results of the field experiments to determine the manurial value of nitrogen, phosphorus and potash under varying conditions of soil, climate, etc., are given as an appendix to this Report.

Weather conditions in 1940.—The total rainfall in 1939 was only 62.7 inches, nearly 20 inches below normal, and actually no rain fell after the 26th October, 1939. There was only .15 inch in January, 1940 and soil moisture had fallen to 10% by the end of this month.

There was fairly good rain in February and exceptionally good rain (5.42 inches) in March, and tea began to come away well. Unfortunately April was abnormally dry (1.55 inches—a record for 23 years) and red spider rapidly became prevalent on all tea, young and mature. Even cut back areas and tea which had been late pruned and well cleaned out suffered considerably.

Although, up to the end of March, there had been very few deaths in the November, 1939, planted area, bushes then began to die rapidly

and the total percentage deaths at the end of the year was 11% over the whole area. This area had no boga medeloa. The 4 acres planted in March under heavy boga medeloa had hardly any deaths. Whether this was due to the late planting or to the green crop cannot of course be ascertained, but it is thought that the green crop benefited the tea. The boga medeloa was put in between every line of tea in March and grew well with the good rain which fell that month. It was barely a foot high by the end of April, but was already shading the soil to a considerable extent and probably was acting to some extent as a wind break to protect the newly planted young tea from the effect of the hot dry winds.

Although there was good rain in May, red spider remained prevalent on mature tea, and the second flush crop for this month was abnormally low. June and July crops were about normal, but in August rainfall was again low (another low record for 23 years) and temperature high; and crop was very short in August and September. The late season crop was fairly good. Of the mature tea the light-leafed jats as a whole were more affected than the dark-leafed. Crops from the Indo-China area were higher than in 1939, but Tingamira, Bazaloni and Betjan (mature) areas gave much lower yields.

The total rainfall for 1940 was 70 inches, eleven inches below normal.

Acreage and Planting.—On the 1st January, 1940, the total area at the Experimental Station under tea was 81.59 acres. In March 4.74 acres of 'Khorijan' jat were planted bringing the total to-date to 86.33 acres. In addition small areas have been put out under tobacco, flax, fodder grass, and derris elliptica, etc., while small extensions have been made to the Tung plantations.

A collection of shade trees commonly used in tea is also growing.

No new planting of tea has been done in the cold weather 1940-41.

The total green leaf plucked during 1940 was 2,815 mds. equivalent to 633 mds. tea (assuming 100 lbs. leaf gives 22½ mds. tea). This gives a crop of 8.6 mds. per acre over the whole planted area (73.5 acres excluding the seed garden and 1939-40 planting).

The highest yielding tea gave 21 mds. per acre, while the lowest top pruned mature tea yielded under 5 mds.

The following areas were cut back in December, 1940:—

To 20"—Tingamira Nitrogen plots Nos. 21-224 ... 2.03 acres.

,, 18"—Matelli Cultivation plots Nos. 90-91 ... 0.6 ,,

According to programme Matelli plots 87-89 and 92-96 were cut back to 18" at intervals up to July, 1940.

On the Dark Mesai Manipuri Nitrogen Experimental block, light hoeing was replaced by cheeling, during the 1940 rains.

All existing experiments were maintained during the year. Manures were applied according to programme in 1940, and adequate supplies were obtained for 1941. It is, however, intended that in 1941, oilcake shall be substituted where possible for artificials on all plots not under manurial experiment so as to conserve existing supplies of artificials in case the expected shortage of these materialises in 1942 and subsequent years.

The work outlined in the Programme for 1940 has been adhered to closely and results that have been obtained are described in the following pages:—

Experiments are in progress to find out the effect of height of cutting and time of year at which medium pruning is done, and its effect on the yield, growth of the bush, and also upon the quality of the tea made.

Tea was cut back in December, 1938, to 4, 12, 20 and 28 inches respectively from the ground. Teas from these areas were manufactured separately during 1940 with the object of ascertaining the effect of the cutting back upon quality. Unfortunately owing to the war conditions the team of tasters suffered very serious depletion and results consequently are not as accurate as they would normally have been. Still they are sufficient to show that in the second year after cutting back the lower the height of cutting the poorer are the teas throughout the second flush and the early rains. The differences however are surprisingly small. During the late rains and the autumnal period there is no difference in the valuation of the teas from the high or the low cut back bushes.

Average valuations over second flush and early rains periods.

Cut back to.	Average valuations. As. Ps.
4 inches	11 7.4
12 ,, ...	11 8.2
20 ,, ...	11 8.7
28 ,, ...	11 10.3

Difference required for significance = 1.35 pies.

Average valuations over late rains and autumnal periods.

Cut back to.	Average valuations.
	As. Ps.
4 inches	14 2.0
12 ,, ...	14 2.8
20 ,, ...	14 1.7
28 ,, ...	14 3.8

No significant differences.

Withering

Experiments have shown that the extent of oxidation after 2 hours of fermentation of tea leaf has a significant correlation with the degree of the wither and that a good fermentation can be obtained as easily with unwithered as with withered leaf, the time of fermentation being if anything shortened. It has been shown that the juice expressed from fresh tea leaf is toxic to many bacteria and that this toxicity decreases as fermentation proceeds.

Rolling

Recent work in the laboratory has shown that undamaged tea leaf undergoes anaerobic fermentation and that this progressively decreases with increasing mechanical damage to the leaf tissues until anaerobic fermentation is completely suppressed. This seemingly academic result has a practical application for it enables an estimation to be made of the mechanical damage done to leaf during either withering or rolling. The complete suppression of anaerobic fermentation indicates that practically all the cells of the leaf have been damaged. Examination of leaf from our own factory as well as from commercial factories has shown that suppression of the anaerobic fermentation can amount to 90-98 per cent indicating that rolling has been very efficiently accomplished. It has also been shown that mechanical damage does not necessarily involve rupture of the cell wall, but may consist in a strain being exerted on the contents of the cell, causing the cytoplasm to become partially permeable by those substances of catechol nature which normally are confined to the vacuole, This result provides evidence of the kind of damage that is required in the rolling process. It is necessary then to rid our minds of the idea that rolling requires the breaking of the cell wall. This idea has in the past led to some misconception of the rolling process.

Fermentation

Whilst it has been impossible to study the effect of humidity on the fermentation of tea it has been possible to continue the work on the effect of variations in time and temperature on fermentation, and on the liquor characteristics and the chemical composition of the tea made.

In the Report for last year attention was called to the need for the study of the condensation of catechol compounds and this still

remains an urgent problem. It has however been possible to devise a method that gives a measure of the condensation that has taken place during manufacture. This is referred to as the condensation index which has been shewn to have a very high correlation with both time and temperature of fermentation. At each time of fermentation there is a steady upward trend in the condensation index as the season advances. A fall in soluble catechol compounds is associated with increasing condensation and this is shown by the high correlation that exists between soluble catechol compounds and the condensation index. It has been found possible to establish relationship between the condensation index and four liquor properties, namely, briskness, strength, colour and quality.

It is now possible to draw some conclusions as to what constituents of the tea leaf are responsible for the various characters of the liquor, recognised by our official taster.

Strength.—Of a tea infusion as measured by its effect upon the taster's palate may be considered as a mild effect due to catechol compounds and may be expected to increase with condensation. It reaches a maximum and after that shows reduction which may be due to the more highly condensed substances combining with the leaf protein and becoming insoluble. The strength of a tea infusion may therefore be considered in terms of catechol bodies.

Colour.—The intensity and the tint of colour of taster's infusion are almost entirely determined by the catechol bodies and their degree of condensation.

Briskness.—The most striking feature perhaps is the very high negative correlation ($R = -.7509$ for $n = 190$) that is found between briskness and the condensation index whereas on .1% probability level the significant value is $R = .321$ for $n = 100$.

There are few substances in a tea infusion which could be considered as conferring briskness, and of these, caffein appears to be the most likely. It has been observed that whereas caffein has little affinity for the unoxidised catechol compounds of green leaf, it does combine in the fermented tea to form the cream which separates from a tea infusion on cooling and which is probably due to the caffein catechol complex. It has been observed that the teas with the highest condensation indices, cream first. If a 5-minute infusion is shaken with chloroform the greater part of the caffein is removed and creaming down when cold no longer takes

place. If caffein be added to the cold caffein-free tea extract creaming down is instantaneous. There is other evidence for the formation of a moderately stable caffein catechol compound in tea as a result of fermentation; which is decomposed at the temperature of boiling water. The indications are that the more highly condensed bodies are concerned in the formation of this complex. Hence an increased extent of complex formation may be expected as condensation increases and in consequence a decrease in the amount of free caffein. The assumption that free caffein is responsible for briskness is therefore in harmony with the observed correlation between briskness and condensation index. A crucial experiment is recognition by the taster of enhanced briskness after the addition of caffein to the ordinary tasting infusion. Our taster was of the opinion that the addition of 100 mds. of caffein to an infusion increased its briskness. The results are of much interest but the work needs to be extended before reaching any final conclusions.

Quality.—Is a characteristic that is very difficult to define. It is believed that one of the factors which make for poor quality is a high amino-acid content, but it is at present inadvisable to say more on this subject.

It is noteworthy that tasters differentiate between quality and flavour.

Moulds

Investigations carried out over a number of years have shown that a mixed flora of moulds exists on fired tea and may be found after tea has been final fired for 15 minutes at 180°F. and that under certain circumstances these moulds may develop. Teas have been kept under different conditions of moisture for several months, and at the end of this period examination has shown that the majority of the moulds have died. Those surviving consisted almost entirely of one species, a dark brown *Aspergillus*.

During the past year a number of samples of spoilt tea from the local markets were examined for mould content and in almost every case the flora was confined to a single species which was identified as *Aspergillus wentii*. The regular appearances of *A. wentii* alone in teas which have gone musty or mouldy suggests that this mould is closely associated with this unpleasant characteristic. Since development of moulds requires a certain moisture percentage, control of moisture in made tea assumes practical importance and suggests a practical application in the shape of the tea storage bins in the factory.

The moisture percentage in a column of tea with its top surface exposed to the atmosphere for 20-24 hours shows a moisture gradation, the top $\frac{1}{2}''$ having a high moisture content whilst below the top $4''$ the moisture content remains at a comparatively low level.

Wide shallow bins expose a relatively large surface area that will pick up a high percentage of moisture, whereas tall narrow bins expose a comparatively small surface area to the atmosphere and consequently a relatively small amount of tea in the bin that will pick up a high moisture percentage. This can best be made clear by an illustration. In the case of a bin 4 ft. deep from which an invoice is packed every eight days, each day's sorting will provide an average depth of $6''$. 33% of this $6''$ depth may rise to say 8% moisture in 24 hours whereas with a tall bin of the same capacity but 12 ft. high a daily layer of $18''$ deep will be formed of which only 11% will increase in moisture content to 8% under the same atmospheric conditions.

This investigation has been continued. Considerable difficulty has been experienced in obtaining desirably accurate technique. This has now been overcome but the number of estimations are still too few to warrant definite conclusions being drawn.

Tea seedlings were inocculated with the spores of the organism that might be the cause of the trouble but none of the seedlings developed the disease. Conditions have not yet been found that bring about the development of the disease in young plants by inocculation.

The field experiments continue to give results confirmatory of previous years. The most noticeable result is the natural reduction during 1939 and 1940 in the number of bushes attacked by the disease. The experiments give evidence that cleaning out the bushes when top pruning results in greater recovery of the bushes as compared with cutting across.

Three field experiments in the Dooars and four in Assam have been carred out for the control of Thread blight.

Two of the experiments in the Dooars have shown that cleaning out when top-pruning has given a beneficial effect as compared with cutting across, but in one experiment the percentage of infection was low and no significant results were obtained—the Manager remarked that the plots all looked very healthy. The Thread blight, in this instance, was doing so little damage that it would not have been profitable to apply any expensive treatment.

The experiments in Assam where bushes were annually cleaned out showed in 3 cases that 1% Burgundy Mixture or 1% Caustic soda solution had an equally beneficial effect and gave better results than lime-wash, or lime-sulphur solution (30° Beaume applied at a dilution of 1 in 10). These two latter treatments gave no improvement over the control.

In recent years a noticeable increase in the number of cankered tea branches has been observed. These cankers were commonly associated with infection by the fungus *Macrophoma theicola*. In some cases however there was no fungus in the dead tissues. It was found that the death of the tissue occurred before any infection had taken place, and that most of the dead tissues remained uninfected by pathogenic fungi for at least a year after damage had been done. Observations in the field made it apparent that the damage was caused either by the sun or by hot wind. An experiment was carried out to ascertain whether pruning, shade, and manuring had any effect on the incidence of the trouble. It became obvious that the damage followed pruning, and the time of pruning appeared to be an important factor. Several experiments at Tocklai showed this. The dark-leafed Manipuri (Matelli) plots were pruned to 18" at different times of the year. The mid-July pruning gave an average of 88% of the bushes showing canker damage after pruning. Pruning early in September showed 82%; pruning at the end of October 51% and pruning in mid-December 13%.

A series of light-leafed Assam indigenous plots were pruned at 12" from the ground at different times of the year. These showed severe damage by pruning in September, much less when pruning was done in November and still less in January. The leaving of 'breathers' or 'kickers' at the time of cutting back did not make any appreciable difference. In this case also it is noticeable that the unmanured plots on which the crop is much lower were damaged less than the manured plots, except those plots that were light-pruned in December which were hardly affected at all.

The other two series of plots, one light-leafed Assam and the other a dark-leafed Manipuri, also show that the time of pruning is an important factor.

Experiments have been carried out to find whether providing shade over the bushes protects them from this damage.

Individual branches were covered with a loose fitting cylinder of paste-board covered with aluminium and black paint on the outside and

inside of the cylinder respectively. It was noticed that, after the branch had been so protected for one month, removal of the shade resulted in formation of canker after one month's exposure during June. This experiment has been elaborated with other means of shading.

The opportunity has been taken to make some observations on the incidence of Red Rust on young tea, 5 years old.

A significant difference was noticed between dark and light leafed plants, the darker leafed being less susceptible.

The attack was significantly less on both jats with the use of potash manure. The greater the application of potash the less the disease for the three levels of potash used. Spraying with Perenox also proved beneficial.

Self pollinations were done at the end of the year on more than 50 selected bushes with the object of classifying into relatively self-fertile and relatively self-infertile groups. Nurseries are now growing with the seed obtained by the self-pollinations.

The observations on the pruning of seed-bearers have been made, but with the Botanist absent on military service it is doubtful when the computation of the results will be done. To do so requires a great deal of work and the data obtained will require very careful scrutiny preferably by the Botanist who was responsible for the scheme of the experiment.

A considerable amount of work has been done on the vegetative propagation of tea by cuttings. The ability with which roots are formed is an individual character which varies with the bush. Different jats considered as a whole show marked differences in the ability to form roots, that is to say, plants of different parental origin show differences in their ability to root from which it is concluded that the ability to form roots on cuttings is genetically conditioned. The Botanist recognises in *Camelliae thea Link.* a linear series of forms with possible divergences of imperceptible gradation from the lightest leaf (Assamica, southern) type to an extreme China (Bohea, northern) type.

The trend from light-leafed to China is regarded, following Russian authors, as a trend of increasing northern characteristics. The capacity of the tea plant to form roots on cuttings is related to its degree of northern attributes and to the darkness of the leaf and the earliness of spring growth, these being northern attributes. Cuttings of green wood showed greater variation than cuttings of red wood in their capacity to

develop roots. The total success per bush for red and green cuttings taken together exhibits the same taxonomic trend. It is concluded that the more northerly the character of a bush the greater will be the success in rootings of cuttings taken therefrom. This is a general relation subject to a large amount of variation.

The superiority of the green to red cuttings varies with the jat. The red cuttings are found on the whole to do less well than the green but in some cases may be better. In general the success of red cuttings relative to green cuttings from the same plant increases in proportion to the northern attributes of the plant. The nett effect of both types of cuttings shows increasingly better rooting as the northern characters of the bush increase.

The rooting characteristics associated with individual bushes are associated also with jats, the expression of jat differences depending upon the uniformity or variability of the bushes in the jat. The variability is not the same in the different jats and the characters considered are not distributed at random amongst the progeny of different trees. They are therefore to be regarded as probably genetically conditioned.

The success of cuttings is found to be in good accordance with the classification types developed in this Station and rooting capacity may provide an useful aid to classification.

At the end of the year 61,223 cuttings from 87 different bushes were put out, in the majority of cases to test the rooting capacity of the cuttings from bushes selected on manufacturing characteristics.

The pre-treatment of cuttings with growth promoting substances did not yield any notable result, which is in agreement with the results obtained at the Tea Research Institute of Ceylon.

The following is a very brief historical resumé of the work done in the vegetative propagation of tea. It should be realised that until the foundation of a Botanical Branch in 1930, all such work had to be fitted in as time and opportunity permitted. It was therefore impossible to carry it out on a large scale.

The tea industry has been fortunate that no outbreak of disease has so far rendered it necessary to replace the existing tea plants by resistant strains. From the very outset of his association with the industry the Mycologist recognised the importance of finding a rapid method of propagating desirable strains. Surprisingly little attention had been

paid to vegetative methods of propagating tea in India, Ceylon and Java until comparatively recent years. In 1914, Dr. Hideo Yamada of Formosa came to Tocklai and incidentally discussed the methods of propagation employed in Formosa. He showed the Mycologist how they made marcots and layers in Formosa. He also stated that woody cuttings rooted fairly well. The Mycologist had already observed that China bushes in Darjeeling produced layers naturally. He tried a number of methods of making woody cuttings. Some cuttings taken in December, 1914, were dipped in molten wax to conserve the moisture during storage. They were then stored in jars in the dark until the following March and April, when they were cut top and bottom and placed in damp soil in the open. A few of these produced small roots but all died eventually. The reason for this lack of success seemed to be the absence of reserves of energy in the stems concerned. In the plains districts there is little starch reserve stored in the stems of tea bushes. In China bushes growing in Darjeeling there is usually considerable starch reserve in the woody branches and woody cuttings may grow more satisfactorily there.

Root cuttings were next tried without success. The attempt was abandoned during the war years (1914-1918), on account of pressure of other work and shortage of staff.

The Mycologist's interest was again stimulated by the visit in 1920 of Mr. St. George Showers who had experimented on budding and grafting tea bushes in his green-house in England. A few buds and grafts were made, some of which survived until 1921, when Dr. Fumio Maruo of Shizouka, Japan, paid us a visit. We showed him our attempts and he told us the Japanese methods of obtaining layers and woody cuttings. We had another try with woody cuttings with little success. In the meantime nothing of this kind appears to have been done in Ceylon and little in Java. In any case layering or woody cuttings would not be likely to give the rapid increase required should it be desirable to replace comparatively large areas with plants propagated from a few selected bushes. It seemed necessary to use seed for this purpose.

One of the difficulties in using seed is that seed does not produce plants identical with the parent tree. It seemed desirable therefore to find a method by which various characters in the parent tree may be recognised in the progeny at the seedling stage. At that time a number of young men were anxious to get experience as unpaid probationers in our laboratories. With the help of these men the Mycologist was able to collect large numbers of measurements of leaves of both parents and progeny. The results were inconclusive.

In 1926, more cuttings were tried. This time leaves were left on the woody cuttings but still with no success.

Another attempt was in progress with somewhat younger cuttings when Mr. H. Clark, Manager of Subong Tea Estate, Cachar, demonstrated grown roots on some plucking shoots. Later he successfully grew a tea bush from a green shoot cutting. The Mycologist therefore planted a series of shoots in good open textured soil and kept them in a saturated atmosphere in a glass case in his laboratory. Many of these produced satisfactory roots and later became satisfactory bushes.

In 1930, the prospect of the appointment of a Botanist stimulated further development. The Mycologist had hoped to find a method which could be used on a large scale for the propagation of strains of tea selected by the Botanist in the course of his work. In our "Quarterly Journal", Part I, 1931, a short article was published recording the success obtained. This elicited a letter from Prof. Kwarazkhelia referring to his own work on the vegetative propagation of tea. In 1933, he published in the "Tropical Agriculturist of Ceylon" a series of very useful illustrated articles on the vegetative propagation of tea. About the same time work on vegetative propagation was also proceeding in Java but more attention was given to layering, budding and grafting than to cuttings. Later on considerable attention was given to the same subject in Ceylon.

In 1932 and subsequent years, the Mycologist continued to give some attention, as time permitted, to this method of propagation. He wanted to find out how to obtain a large number of plants from an individual bush in the course of a single season. This could not be done if whole shoots were used. Single fully grown leaves with buds on their axils were tried. This was successful. In the course of the work it was found that the highest percentage of successful plants were obtained from the middle leaves on the leaf cycle. It was also observed that tea plants differed considerably in their ability to yield freely rooting cuttings. This work was handed over to the Botanist who has developed the method still further and is using it on a large scale for the propaganda of selected tea plants.

The experiment at Tocklai whilst still in its very early stages is yielding some interesting preliminary results which show that in this experiment nitrogenous manure gives a far smaller effect when applied to bushes under shade than to bushes unshaded.

The use of 60 lbs. of nitrogen per acre on unshaded tea has given an increase of 1.75 mds. per acre of tea while on the shaded area the increase due to 60 lbs. of nitrogen is 1.04 mds. per acre.

In the absence of manuring, shade has given a very significant increase in crop of just over 1 md. per acre but the manured and shaded area gave only 1.98 mds. per acre increase whereas if both shade and manures were to give their full increase they would have given 1.75+1.04=2.79 mds. tea per acre more than the unshaded and unmanured tea. This difference is what is known as an interaction, and in this case, since it is less than the sum of the two, it is a negative interaction. That is to say the presence of shade reduces the effect of nitrogenous manure on tea. This suggests that in these days of economy and shortage of manures well shaded areas can be left unmanured, the manure being applied only to those bushes on the area which are outside the immediate influence of the shade trees.

Other experiments dealing with shade are in progress on commercial estates. So far only 3 have advanced sufficiently to yield results of interest. In one instance an interesting interaction is to be noticed with phosphate and potash. The phosphate tends to increase the negative interaction whilst there is a positive interaction with potash. This is an important finding and further results will be awaited with much interest.

Phosphate applied with nitrogen aggravates the negative interaction between shade and nitrogenous fertilisers. Since phosphates are beneficial to the growth of shade trees, it is only reasonable to expect that the more vigorous a shade tree the more pronounced will be its effect. If, then, shade is beneficial on unmanured areas, phosphate may be expected to increase the beneficial effect. On the other hand shade has a detrimental effect on areas where nitrogenous manures are used. Application of phosphate by increasing this effect will be harmful, probably through stimulating the shade tree to utilise more of the nitrogen given. These are not to be regarded as conclusive, but only as preliminary and interesting, results, which require that experimental work on shade trees shall be not only continued but also extended as much as possible.

Whilst it is realised that the application of nitrogenous manures to shaded areas do not give the same increase as would be obtained from the same application of nitrogen on an unshaded area yet it is of interest to know what form the interference of the shade takes.

An experiment is in progress in which 0, 20, 40, 60 and 80 lbs. nitrogen as sulphate of ammonia respectively has been added per acre to tea planted 5 ft. triangular shaded with sau trees 50 ft. apart. The results show that the increase in crop is directly proportional to the nitrogen applied that is to say if an application of 20 lbs. of nitrogen per acre

produces a certain increase then 60 lbs. of nitrogen per acre will produce about 3 times that increase on shaded tea.

Other experiments are being carried out dealing with the distance apart of shade trees, the variety of shade trees, and the interaction between variety and manuring. It will however be some years before these yield any definite results.

Compost and Cattle Manure

The results of experiments carried out at Tocklai and on 11 tea estates situated in Assam, the Dooars and the Surma Valley continue to show results very similar to those given in Tocklai Experimental Station Memorandum No. 11 "Experiments with Cattle manure, Humus composts, etc."

After 4 or 5 years these experiments have failed to show the cumulative manuring effect which such slow-acting manures are popularly supposed to have. Cattle manure and compost appear to have about one-third to one-half the efficiency of sulphate of ammonia on the total nitrogen basis. The raw materials used for making composts by both the Indore and Dacca methods may give results as good or better than the same materials after composting. The case against composting for mature tea is thus still further strengthened.

An experiment with the application of cut jungle (Eupatorium) at the rates of 3 and 6 tons per acre respectively have given crop increases approximately equivalent to those from 150 lbs. and 300 lbs. of Sulphate of ammonia respectively. The cut jungle at the time of application contained approximately 0.66% of nitrogen. In this form it has about 65% the efficiency of the same quantity of nitrogen in the form of Sulphate of ammonia.

An experiment in the ninth year of application with oil cake (Rape containing 4.5 to 5% nitrogen) at the rate of 60 lbs. of nitrogen per acre has given an increase of 5.76 mds. per acre of tea over the plots unmanured whereas sulphate of ammonia has given an increase for the same application of nitrogen of 7.51 mds. per acre. The efficiency of oil cake is thus approximately 77% that of sulphate of ammonia.

Autumnal versus Spring Manuring

Manuring in the autumn, October 5th 1939, has given a just significant increase of 0.29 mds. per acre of first and second flush tea, to the end of June, compared with spring manuring, March 26th 1940, but the crop to the end of the year is 0.16 mds. higher in the case of March manuring but this is not a significant difference.

Nitrogen, Phosphate and Potash Manuring

The application of 60 lbs. of phosphoric acid to young tea gave a significant increase of .53 mds. per acre in 1940. The use of this manure has greatly increased weed growth in the tea in this experiment,

particularly that of a creeping grass *Paspalum sanguinale*. Weighments of weed growth in June, three weeks after hoeing, showed that no phosphoric acid resulted in weed growth amounting to less than 1 ton per acre. 20 lbs. of phosphoric acid increased the weed growth by 2¼ tons whilst 60 lbs phosphoric acid increased it by over 3 tons.

Experiments to ascertain the value of nitrogen, phosphate and potash as manure for mature tea have been continued. The experiment at Tocklai continues to show similar results as in the past, and 33 field experiments on tea estates, viz.,

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have all shown an increase from the use of nitrogen and in the majority of cases this increase is significant.

Potash and phosphate have seldom given significant results.

One experiment only on an Assam sandy soil has shown significant increase from the use of potash. Nevertheless if the results from all the 8 Assam gardens on sandy soils are taken together the mean increase in crop per acre amounts to .28 mds. and is just significant. Such a small increase from the application of 40 lbs. of potash per acre is not to be considered generally economic.

iment to ascertain the value of deep and light hoeing during
her and the rains has now been under treatment for two

ble effect of deep cultivation and light cultivation during
of the year, that is to say during the cold weather and
resulted in an increase in Red spider attack. This, it is
be due to the damage done to the surface roots, and to
of the soil. Light hoeing also during the rains period
ider. It is not easy to offer an explanation for this since
owledge that areas poorly cultivated so as to be infested
as thatch grass, are also prone to Red spider attack.
area is free from thatch and coarse grasses.

m that cultivation must be limited to just that amount
o keep the area clean of weeds and that anything beyond
he cold weather, the spring or the rains, can do harm.

APPENDIX.

Field Experiments on Tea Estates.

field experiments on tea estates to ascertain the
nitrogen, phosphate and potash are given in the accompanying tables yields being expressed in maunds tea per acre.

N. P. K. EXPERIMENTS.

ASSAM.

SAUDY SOILS	NIL	N	NP	NK	N. P. K.	S. D.	P.	K.	P X K	S. D.	"Z"
Orangajuli	14·71	14·89	15·35	15·63	15·01	0·94	−·08	+·20	−·34	0·66	Not Passed
Seajuli	5·99	9·67*	9·55*	10·10*	10·02*	0·84	−·10	+·90*	+·02	0·59	Passed
Oaklands	12·26	12·44	12·78*	13·04*	12·71*	0·45	0	+·26	−·38*	0·32	Passed
Rajmai	12·9	13·3	12·8	12·7	13·1	0·89	0	−·15	+·5	0·62	Passed
Digulterang	9·67	10·64*	10·59*	10·75*	10·85*	0·50	+0·03	+·18	+·07	0·35	Passed
Tezpore and Gogra	7·60	9·84*	9·48*	9·36*	9·50*	0·64	−·11	−·23	−·25	0·45	Passed
Tezpore and Gogra	11·00	11·90	11·62	12·50	12·78	2·7	−·01	+·89	+·27	1·89	Not Passed
Tezpore and Gogra	6·58	7·37	7·87	8·58	8·06	2·47	−·01	+·70	−·50	1·75	Not Passed
RED BANK											
Tezpore and Gogra	9·02	10·91*	10·82*	10·51*	11·06*	0·93	+·23	−·08	+·32	0·66	Passed
Tezpore and Gogra	10·89	12·75*	12·26*	11·91*	12·17*	0·99	−·12	−·46	+·37	0·70	Passed

S. D. = Significant difference at p = 0·05.

N. P. K. EXPERIMENTS.

SURMA VALLEY.

CACHAR PLATEAU AND TEELA SOILS	Nil	N	NP	NK	NPK	S. D.	P	K	P X K	S. D.	"Z"
Dargakuna	5·65	7·71*	9·25*	8·57*	8·33*	0·89	+0·65	−0·3	−0·89	0·63	Passed
Koomber	2·89	3·85*	3·93*	4·06*	4·08*	0·83	+0·05	+0·18	−0·06	0·59	Not passed
Khoreel	7·38	10·39*	10·35*	11·19*	10·69*	1·16	−0·27	+0·57	−0·46	0·82	Passed
Rajghat	13·18	15·51*	15·42*	14·49*	15·09*	1·29	+0·25	−0·67	+0·69	0·85	Passed
Karkoorie	2·73	2·86	2·94	2·93	2·93	0·28	+0·04	+0·03	−0·09	0·197	Not passed
Seriepore	18·26	20·02*	20·96*	19·14	19·97*	1·42	+0·89	−0·93	−0·11	1·004	Passed
Silcoorie	Preliminary yields taken in 1940										
Tilkah	20·76	22·32	22·42	21·62	21·77	1·75	+0·12	−0·67	+0·64	1·24	Not passed
Koombergram	4·89	6·01*	5·57	5·68	5·70	0·83	−0·21	−0·10	+0·46	0·59	Not passed
CLAY FLATS											
Ruttonpore	2·20	3·63	4·23*	3·87	5·01*	1·69	+0·87	+0·51	+0·27	1·19	Passed
Chandipore	5·16	8·17*	6·78	7·51*	8·08*	1·77	−0·41	+0·32	+0·98	1·25	Passed

N. P. K. EXPERIMENTS—(contd.).

SURMA VALLEY.

HEAVY FLATS STILL RICH	Nil	N	NP	NK	NPK	S. D.	P	K	P X K	S. D.	"Z"
Singalla	13·44	15·76*	16·42*	15·70*	16·82*	1·82	+0·89	+0·17	+0·23	1·28	Passed
RICH HUMUS SOILS											
Luckynugger	10·47	11·10	11·53	11·52	11·99	1·60	+0·45	+0·42	+0·04	1·13	Not passed
Poloi	13·8	15·3	15·4	15·0	14·5	1·71	−0·22	−0·65	−0·28	1·21	Not passed
DETERIORATED HUMUS SOILS											
Lallacherra	10·84	13·63	12·76	13·97*	14·57*	3·11	−0·14	+1·08	+1·47	2·05	Not passed
Lallamookh	7·56	10·95*	11·00*	11·59*	11·19*	1·55	−0·201	+0·826	+0·103	1·09	Passed
RICH RED LOAM ON FLAT											
Burnie Braes	11.8	17·9*	17·2*	16·0*	18·1*	2·72	+0·7	−0·5	+1·4	1·9	Passed

N. P. K. EXPERIMENTS.

DOOARS.

LIGHT SOILS.	Nil	N	NP	NK	NPK	S. D.	P	K	P X K	S. D.	"Z"
Baradighi	11·56	12·37	13·66*	12·70*	13·36*	1·26	+·64	+·11	−·21	0·89	Passed
Bhatkawa	21·32	21·88	23·73*	23·40*	23·97	1·33	+1·21	+·88	−·64	1·29	Passed
Kartick	16·31	17·67	18·40*	18·87*	18·14*	1·46	+·08	0	−·56	1·03	Passed
Rydak	15·11	16·73*	16·73*	17·60*	17·08*	·98	−·26	+·61	−·26	0·69	Passed
RED BANK											
Matelli	8·09	10·83*	12·53*	11·60*	11·45*	0·54	+0·78*	−·16	−·93*	0·37	Passed
Mortee	7·79	13·38*	13·95*	12·91	13·15*	1·27	·35	−·64	−·16	0·89	Passed